SOLOMON RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Water Body: Waconda Lake
Water Quality Impairment: Eutrophication

Subbasin: Solomon River

Counties: Jewell, Mitchell, Norton, Osborne, Phillips, Rooks, and Smith

HUC 8: 10260012 **HUC 11** (14)**: 010** (010, 020, 030, 040, 050, 060, 070) (Figure 1)
020 (010, 020, 030, 040, 050, 060, 070)
030 (010, 020, 030, 040, 050, 060, 070, 080, 090, 100)
040 (010, 020, 030, 040, 050, 060, 070, 080, 090)

10260014 **HUC 11** (14)**: 010** (010, 020, 030, 040, 050, 060)
020 (010, 020, 030, 040, 050, 060, 070)
030 (010, 020, 030, 040, 050, 060, 070)
040 (010, 020, 030, 040, 050, 060)

10260015 **HUC 11** (14)**: 010** (010, 020, 030)

Ecoregion: Central Great Plains, Rolling Plains and Breaks (27b)

Drainage Area: Approximately 2,490 square miles.

Conservation Pool: Area = 9,784 acres
Watershed Area: Lake Surface Area = 163:1
Maximum Depth = 14.0 meters (45.9 feet)
Mean Depth = 5.7 meters (19 feet)
Retention Time = 0.85 years (10 months)

Designated Uses: Primary and Secondary Contact Recreation; Expected Aquatic Life Support; Drinking Water; Food Procurement; Groundwater; Industrial Water Supply; Irrigation

Authority: Federal (U.S. Bureau of Reclamation) and State (Kansas Dept. of Wildlife and Parks)

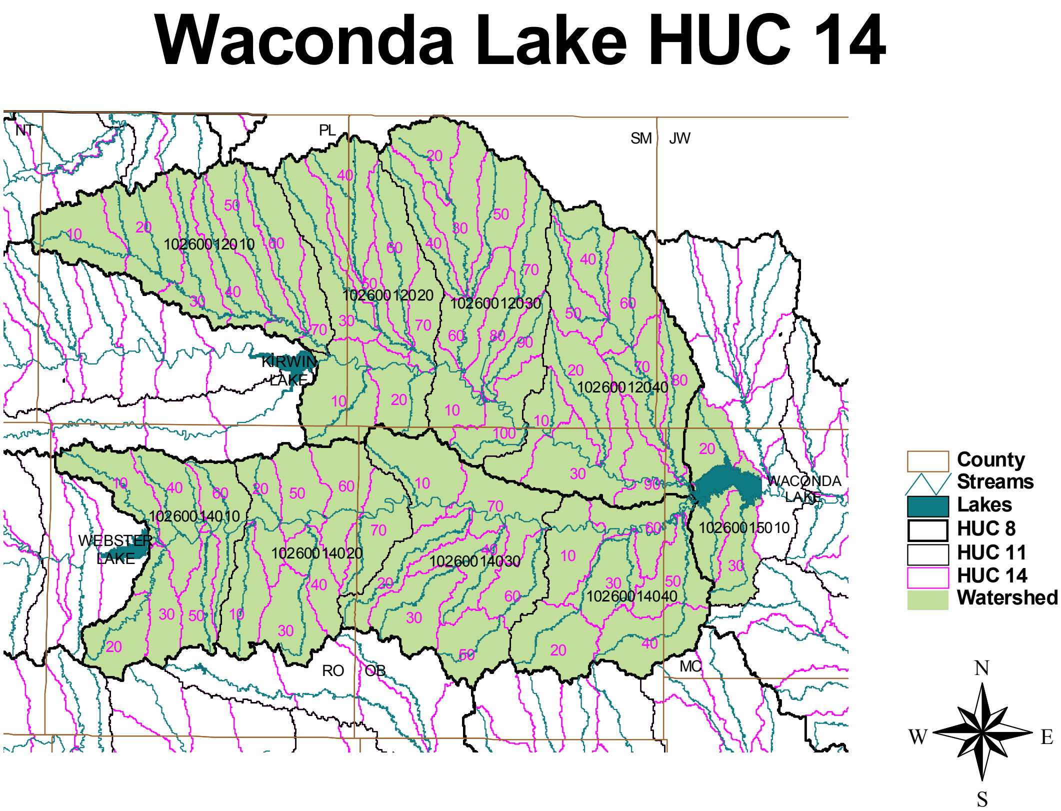
2002 303(d) Listing: Solomon River Basin Lakes

Impaired Use: All uses are impaired to a degree by eutrophication

Water Quality Standard: Nutrients - Narrative: The introduction of plant nutrients into streams, lakes, or wetlands from artificial sources shall be controlled to prevent the accelerated succession or replacement of aquatic biota or the production of undesirable quantities or kinds of aquatic life. (KAR 28-16-28e(c)(2)(B)).

The introduction of plant nutrients into surface waters designated for primary or secondary contact recreational use shall be controlled to prevent the development of objectionable concentrations of algae or algal by-products or nuisance growths of submersed, floating, or emergent aquatic vegetation. (KAR 28-16-28e(c)(7)(A)).

Figure 1



2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Eutrophication: Fully Eutrophic, Trophic State Index = 59.04

Lake Monitoring Site: Station 018001 in Waconda Lake (Figure 2).
Period of Record Used: Six surveys during 1986 - 2001
Elevation Record: Waconda Lake at Glen Elder, KS (USGS Gage 06874200)

Stream Chemistry Monitoring Site: Station 014 at Portis (North Fork Solomon River)

Period of Record Used: 1985 - 2002

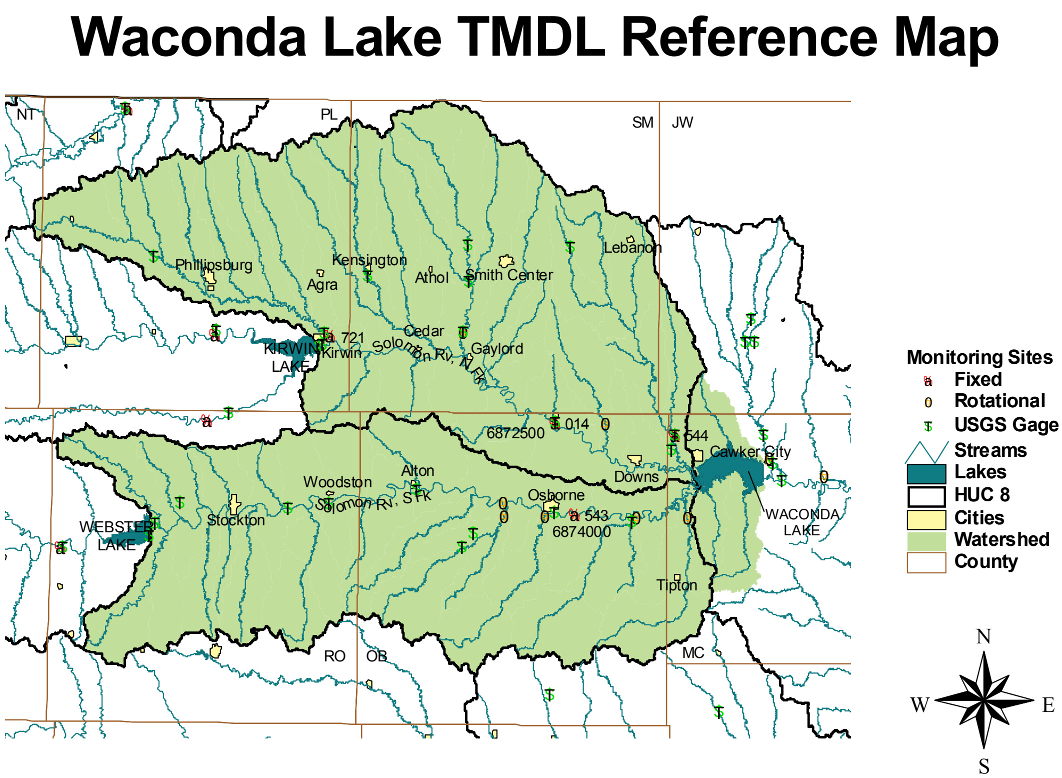
Flow Record: North Fork Solomon River at Portis, KS (USGS Gage 06872500)

Stream Chemistry Monitoring Site: Station 543 below Osborne (South Fork Solomon River)

Period of Record Used: 1990 - 2002

Flow Record: South Fork Solomon River at Osborne, KS (USGS Gage 06874000)

Figure 2



Current Condition: In 2001, Waconda Lake was slightly eutrophic. The lake had chlorophyll a concentrations averaging 8.6 μg/L, a Total Phosphorus concentration of 41 μg/L, a Total Kjeldahl Nitrogen concentration of 0.85 mg/L, and nitrate and nitrite were below the detection limit (Appendix A). Light was indicated to be the primary limiting factor due to clay turbidity (Appendix B). The chlorophyll a to total phosphorus yield was moderate.

Between 1992 and 1998, Waconda Lake was impaired and very eutrophic with a Trophic State Index of 63.86. The average chlorophyll a concentration was 29.8 μg/L, and the total phosphorus concentration was 82 μg/L. The Total Kjeldahl Nitrogen concentrations averaged 1.25 mg/L; nitrate concentrations averaged 0.07 mg/L; and nitrite was below the detection limit. Light was indicated to be the primary limiting factor due to clay turbidity, and nitrogen was a secondary limiting factor. The lake was not impaired prior to the 1992 sampling period.

Based on the load duration curves in Appendix C, the magnitude of the exceedences is greatest during high flow events. There are exceedences at high and low flows implying that both nonpoint and point source pollution respectively are contributing factors in the Waconda watershed.

The Trophic State Index is derived from the chlorophyll a concentration. Trophic state assessments of potential algal productivity were made based on chlorophyll a concentrations, nutrient levels and values of the Carlson Trophic State Index (TSI). Generally, some degree of eutrophic conditions is seen with chlorophyll a concentrations over 7 μg/l and hypereutrophy occurs at levels over 30 μg/l. The Carlson TSI, derives from the chlorophyll concentrations and scales the trophic state as follows:

1. Oligotrophic TSI < 40
2. Mesotrophic TSI: 40 - 49.99
3. Slightly Eutrophic TSI: 50 - 54.99
4. Fully Eutrophic TSI: 55 - 59.99
5. Very Eutrophic TSI: 60 - 63.99
6. Hypereutrophic TSI: $\geq$ 64

Interim Endpoints of Water Quality (Implied Load Capacity) at Waconda Lake over 2008 - 2012:

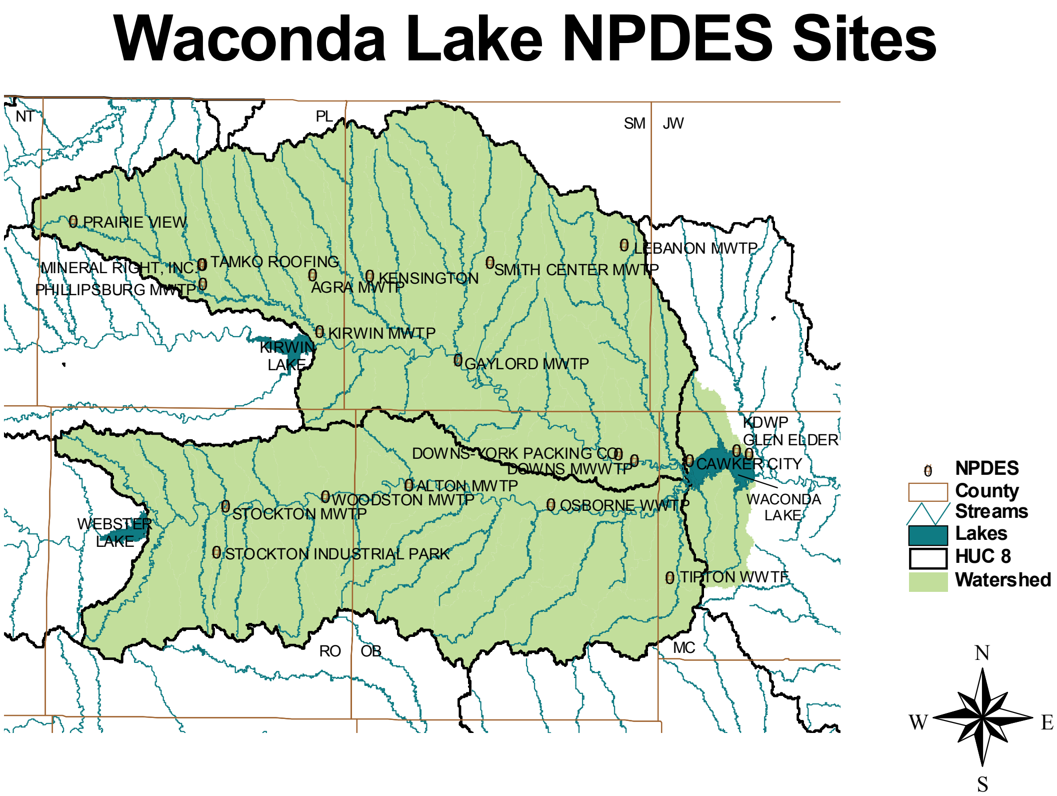
The desired endpoint will be to maintain summer chlorophyll a concentrations below 12 μg/L. Total Nitrogen concentration in the lake should be maintained below 0.62 mg/L. A regression of 2000 - 2001 lake data and 1997 - 2000 wetland data was used to determine the current, in-lake nitrogen concentration and to calculate how much of a nutrient reduction was need to meet water quality standards.

Current Condition and Reductions for Waconda Lake

Parameter	Period of Record	TMDL	Percent Reduction
Total Phosphorus Load (lb/year)	312,470	114,167	63 %
Total Phosphorus Concentration (μg/L)	56	35	38 %
Chlorophyll a (μg/L)	18.2	< 12	34 %
Total Nitrogen Concentration (mg/L)	1.17	< 0.62	47 %

3. SOURCE INVENTORY AND ASSESSMENT

Figure 3



NPDES: Twenty permitted waste treatment facilities are located within the watershed (Figure 3). Eleven are non-overflowing lagoons that are prohibited from discharging and may contribute a nutrient load under extreme precipitation events (flow durations exceeded under 5 percent of the time). Such events would not occur at a frequency or for a duration sufficient to cause an impairment in the watershed. According to projections of future water use and resulting wastewater, the non-overflowing lagoons look to have sufficient treatment capacity available.

Waste Treatment Plants in the Waconda Lake Watershed

Kansas Permit Number	Name	Type	Design Capacity (MGD)	TP Wasteload Allocation	TN Wasteload Allocation
F-SO08-OO01	CAWKER CITY - WACONDA RES.	Three-cell lagoon	0.085	1.42 lb/day	4.97 lb/day
I-SO12-NP01	DOWNS-YORK PACKING CO.	six-cell lagoon	non-overflowing	0 lb/day	0 lb/day
I-SO31-PO01	TAMKO ROOFING PRODUCTS,INC.	aerated cells	monitor (average 0.027 in 2002)	0.09 lb/day	0.34 lb/day
I-SO41-NO02	STOCKTON	two wastewater	non-overflowing	0 lb/day	0 lb/day

	INDUSTRIAL PARK	systems			
M-SO01-NO01	AGRA MWTP	Three-cell lagoon	non-overflowing	0 lb/day	0 lb/day
M-SO02-NO01	ALTON MWTP	Three-cell lagoon	non-overflowing	0 lb/day	0 lb/day
M-SO12-OO01	DOWNS MWTP	Trickling Filter	0.15	4.38 lb/day	25.05 lb/day
M-SO15-NO02	GAYLORD MWTP	Three-cell lagoon	non-overflowing	0 lb/day	0 lb/day
M-SO18-NO02	KDWP - GLEN ELDER(EAST)	Three-cell lagoon	non-overflowing	0 lb/day	0 lb/day
M-SO18-NO03	KDWP - GLEN ELDER(WEST)	Two-cell Lagoon	non-overflowing	0 lb/day	0 lb/day
M-SO21-OO02	KENSINGTON	Three-cell lagoon	0.055	0.92 lb/day	3.21 lb/day
M-SO22-NO01	KIRWIN MWTP	Two-cell Lagoon	non-overflowing	0 lb/day	0 lb/day
M-SO23-NO01	LEBANON MWTP	Three-cell lagoon	non-overflowing	0 lb/day	0 lb/day
M-SO29-OO02	OSBORNE WWTP	Four-cell Lagoon	0.286	4.78 lb/day	16.72 lb/day
M-SO31-OO01	PHILLIPSBURG MWTP	Activated Sludge	0.35	10.23 lb/day	29.23 lb/day
M-SO33-NO01	PRAIRIE VIEW	Two-cell Lagoon	non-overflowing	0 lb/day	0 lb/day
M-SO38-IO01	SMITH CENTER MWTP	Activated Sludge	0.5	14.61 lb/day	104.38 lb/day
M-SO41-OO01	STOCKTON MWTP	Activated Sludge	0.275	8.04 lb/day	57.41 lb/day
M-SO42-OO01	TIPTON WWTF	Three-cell lagoon	0.023	0.38 lb/day	1.34 lb/day
M-SO43-NO01	WOODSTON MWTP	Three-cell lagoon	non-overflowing	0 lb/day	0 lb/day
		Total	**1.751**	**44.85 lb/day**	**242.64 lb/day**

The point source contribution is derived from monitoring data from the waste treatment plants and other point source pollution contributors. When effluent discharge data is not available, the following concentrations are used to calculate the waste load allocations for waste treatment plant lagoons and municipal mechanical plants:

Average Concentration in Municipal Facilities that Meet Baseline Design

Facility Type	Total Phosphorus	Total Nitrogen
Waste Treatment Plant Lagoon	2.0 mg/L	7.0 mg/L
Mechanical Plant – Trickling Filter	3.5 mg/L	20.0 mg/L
Mechanical Plant – Activated Sludge only fully nitrify	3.5 mg/L	25.0 mg/L
Mechanical Plant – Activated Sludge fully nitrify and de-nitrify	3.5 mg/L	10.0 mg/L

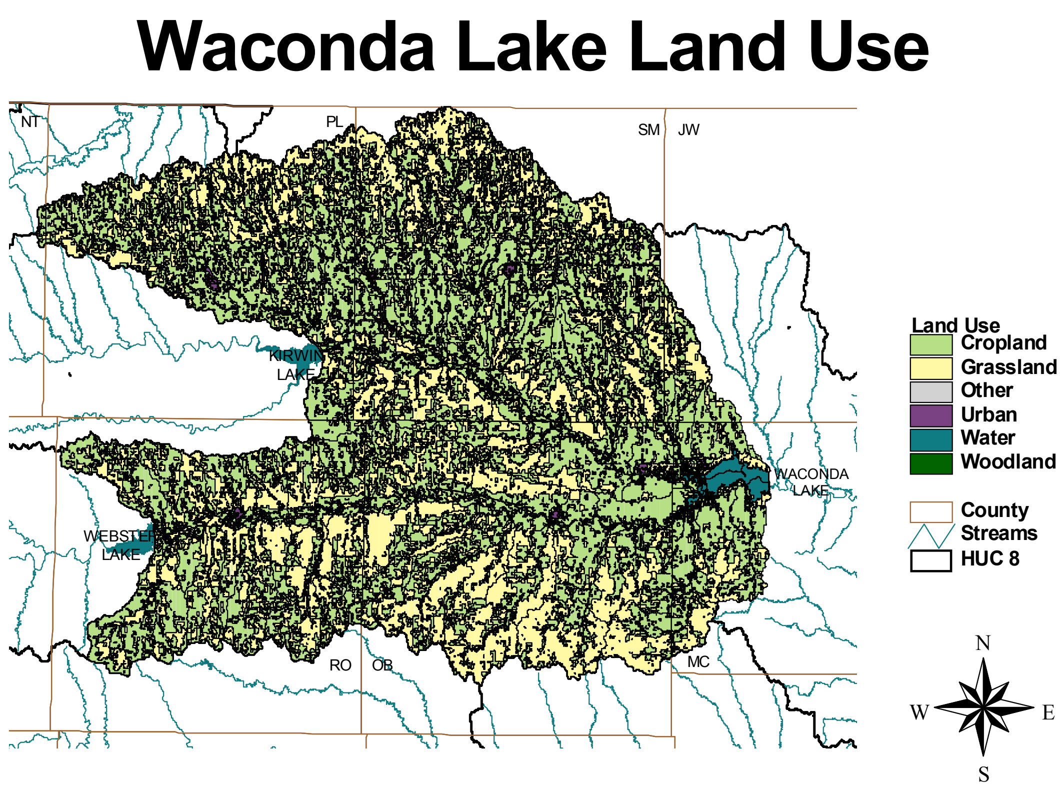
The waste load allocations of industrial facilities are calculated based on baseline design standards for that specific type of facility. If design standards for total phosphorus and total nitrogen are not in place, then best professional judgment is used.

The Downs, Phillipsburg, Smith Center, and Stockton MWTPs discharged 0.18 MGD, 0.36 MGD, 0.21 MGD, and 0.18 MGD respectively based on effluent discharge data from 2002. Cawker City, Kensington, Osborne, and Tipton MWTP did not discharge during the last year. The actual flow and total phosphorus load (January to December of 2002) was used to calculate the Wasteload Allocation for Tamko Roofing Products. Tamko did not discharge from February to December of 2002.

Land Use: The watershed around Waconda Lake has a moderate to high potential for nonpoint source pollutants. A median, annual phosphorus load of 312,470 pounds per year is necessary to correspond to the concentrations seen in the lake. One source of phosphorus within Waconda

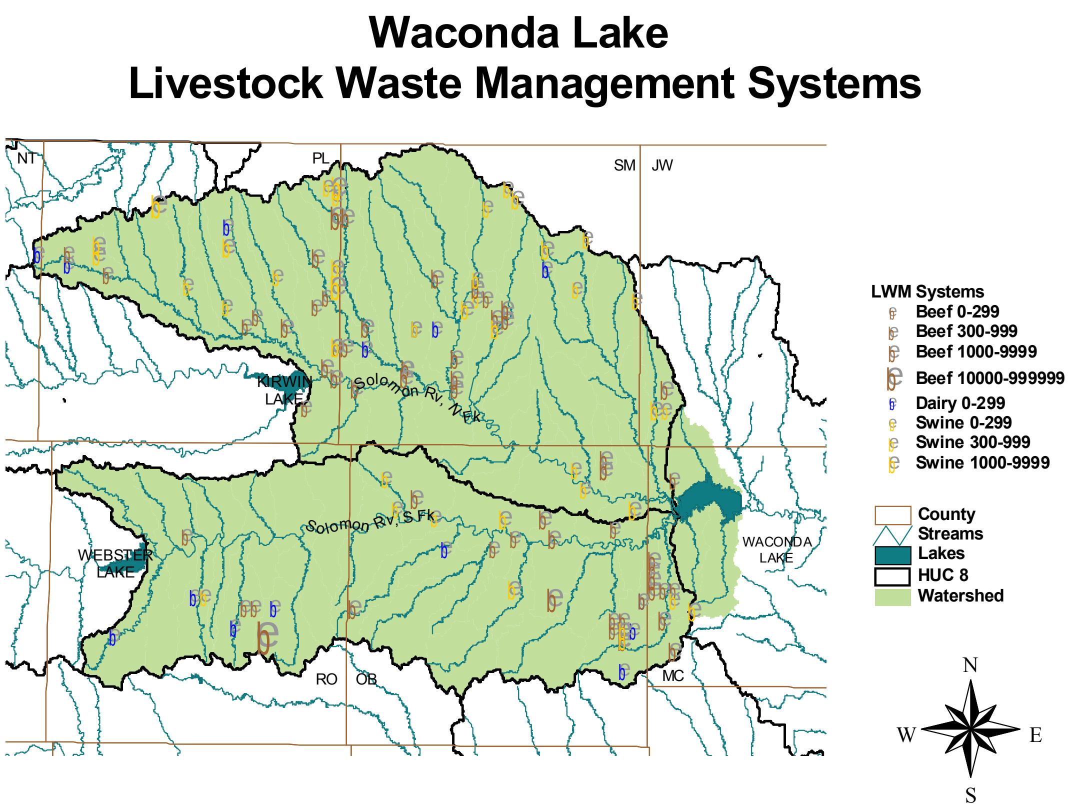
Lake is probably runoff from agricultural lands where phosphorus has been applied. Land use coverage analysis indicates that 54.5% of the watershed is cropland (Figure 4).

Figure 4



Phosphorus and nitrogen from animal waste are a potential contributing factor. Animal waste, from livestock waste management systems, may add to the phosphorus and nitrogen loads going into the lake (Figure 5). However, given the controls for the systems, animal waste coming from grazing areas is a more likely contributor. Forty-three percent of land around the lake is grassland. There are 60 beef, 42 swine, 15 dairy, and 7 combination animal feeding operations in the watershed. Seven of these facilities are NPDES permitted, non-discharging facilities with 25,636 animal units. All permitted livestock facilities have waste management systems designed to minimize runoff entering their operations or detaining runoff emanating from their areas. Such systems are designed to retain the 25 year, 24 hour rainfall/runoff event, as well as an anticipated two weeks of normal wastewater from their operations. Such a rainfall event typically coincides with stream flows which are exceeded 1-5 percent of the time. Therefore, events of this type, infrequent and of short duration, are not likely to add to chronic impairment of the designated uses of the waters in this watershed. Requirements for maintaining the water level of the waste lagoons a certain distance below the lagoon berms ensure retention of the runoff from the intense, local storms events. In Mitchell County, where many of the facilities are relatively close to the river, such an event would generate 5.3 inches of rain, yielding 4.2 to 5.0 inches of runoff in a day. Permit compliance data was examined, and no evidence of spills was detected. Potential animal units for all facilities in the watershed total 69,219 (active: 65,249 animal units; inactive: 3,970 animal units). The actual number of animal units on site is variable, but typically less than potential numbers.

Figure 5



Permitted Livestock Waste Management Systems in the Watershed

Kansas Permit Number	Livestock Waste Management System	Wasteload Allocation
A-SOPL-H002	Premium Pork, Inc.	0 lb/day
A-SOPL-C001	Ferguson Bros., Inc.	0 lb/day
A-URPL-H008	Taylor Swine, Llc.	0 lb/day
A-SORO-C001	* Rooks County Feeders LLC	0 lb/day
A-SOSM-C002	MPK Land & Livestock Llc	0 lb/day
A-SOOB-C001	R & L Feeders	0 lb/day
A-SOPL-H003	Grunts & Grain Farms	0 lb/day

* The facility is not in compliance with the existing permit. Corrective actions are being taken by the KDHE Livestock Management Program.

All of the towns in the watershed anticipate a population decline except for Agra and Cawker City. Less than one percent of the watershed is urban; stormwater runoff and urban fertilizer applications are a minor contributing factor. The average population density in the watershed is 6.3 people per square mile.

Population Trends for Towns in the Watershed

Town	% Change from 2000 to 2020	Town	% Change from 2000 to 2020
Agra	1.7	Lebanon	-19.2
Alton	-10.1	Osborne	-15.4
Athol	-16.9	Phillipsburg	-2.4
Cawker City	0.5	Portis	-3.3
Cedar	-13.0	Prairie View	-15.8
Downs	-11.1	Smith Center	-16.7
Gaylord	-19.2	Stockton	-1.3
Kensington	-19.1	Tipton	-15.3
Kirwin	-7.2	Woodston	-8.6

A potential source is septic systems located around the lake. Failing septic systems can be a significant source of nutrients. The Mitchell County has 735 septic systems, accounting for 22 % of the sewage systems present in the county.

Contributing Runoff: The watershed's average soil permeability is 1.3 inches/hour according to NRCS STATSGO database. About 90.5% of the watershed produces runoff even under relatively low (1.5''/hr) potential runoff conditions. Runoff is chiefly generated as infiltration excess with rainfall intensities greater than soil permeabilities. As the watersheds' soil profiles become saturated, excess overland flow is produced. Generally, storms producing less than 0.5"/hr of rain will generate runoff from 4.6% of this watershed, chiefly along the stream channels.

Background Levels: The atmospheric phosphorus and geological formations (i.e., soil and bedrock) may contribute to phosphorus loads. Nutrients from wildlife waste are another contributing factor.

4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

Total Phosphorus is allocated under this TMDL, because maintaining the current phosphorus load will have a large effect on the managing the algal community. The Load Capacity is 114,167 pounds per year of total phosphorus and was calculated using the CNET model. More detailed assessment of sources and confirmation of the trophic state of the lake must be completed before detailed allocations can be made. The general inventory of sources within the drainage does provide some guidance as to areas of load reduction. Because of atmospheric deposition, initial allocations of nitrogen will be based on a proportional decrease in nitrogen between the current condition and the desired endpoint.

Point Sources: There are eleven non-overflowing and nine discharging waste treatment plants in the watershed. Ongoing inspections and monitoring of these NPDES sites will be made to ascertain the contributions that have been made by the source. These Waste Treatment Plants should comply with any future permit limits. The Wasteload Allocation for the nine discharging waste treatment plants should be at 16,370 pounds of total phosphorus per year and 88,563 pounds of total nitrogen per year. (See page 6 for the Wasteload allocations for each waste treatment plant). As previously noted in the inventory and assessment section, sources such as non-discharging permitted municipal facilities and livestock waste management systems located within the watershed do not discharge with sufficient frequency or duration to add to an impairment in the lake.

Nonpoint Sources: Nonpoint source pollutants contribute nutrients to the Waconda Lake watershed. Background levels may be attributed to wildlife and geological sources. The assessment suggests that cropland and animal waste contribute to the total phosphorus concentrations in the lake. Generally a Load Allocation of 86,380 pounds of total phosphorus per year. A proportional decrease of 42% in nitrogen loading will allow the total nitrogen endpoint to be achieved.

Defined Margin of Safety: The margin of safety provides some hedge against the uncertainty of variable annual total phosphorus load and the chlorophyll a endpoint. Therefore, the margin of safety will be 11,417 pounds per year of total phosphorus taken from the load capacity subtracted to compensate for the lack of knowledge about the relationship between the allocated loadings and the resulting water quality. For nitrogen, the margin of safety will be an additional 5% reduction in nitrogen to ensure that the endpoint is reached.

State Water Plan Implementation Priority: Because Waconda Lake has a large regional benefit for recreation, this TMDL will be a Medium Priority for implementation.

Unified Watershed Assessment Priority Ranking: Waconda Lake lies within the Solomon River (HUC 8: 10260015) with a priority ranking of 23 (High Priority for restoration).

Priority HUC 11s: The HUC 11 (10260015 010) is adjacent to Waconda Lake, and thus the Solomon River subwatershed should take priority.

5. IMPLEMENTATION

Desired Implementation Activities

There is an excellent potential that agricultural best management practices will allow full protection of Waconda Lake. Some of the recommended agricultural practices are as follows:

1. Implement soil sampling to recommend appropriate fertilizer applications on cropland.
2. Maintain conservation tillage and contour farming to minimize cropland erosion.
3. Install grass buffer strips along streams.
4. Reduce activities within riparian areas.
5. Implement nutrient management plans to manage manure application to land.

Implementation Programs Guidance

Fisheries Management - KDWP

a. Assist evaluation in-lake or near-lake potential sources of nutrients to lake.
b. Advise county on applicable lake management techniques which may reduce nutrient loading and cycling in lake.

Nonpoint Source Pollution Technical Assistance - KDHE

a. Support Section 319 demonstration projects for reduction of sediment runoff from agricultural activities as well as nutrient management.
b. Provide technical assistance on practices geared to establishment of vegetative buffer strips.
c. Provide technical assistance on nutrient management in vicinity of streams.
d. Create a Watershed Restoration and Protection Strategy for HUC 10260015.

Livestock Waste Management - KDHE

a. Take corrective actions to ensure that facilities comply with existing permits.

Water Resource Cost Share Nonpoint Source Pollution Control Program - SCC

a. Apply conservation farming practices, including terraces and waterways, sediment control basins, and constructed wetlands.
b. Provide sediment control practices to minimize erosion and sediment and nutrient transport.

Riparian Protection Program - SCC

a. Establish or reestablish natural riparian systems, including vegetative filter strips and streambank vegetation.
b. Develop riparian restoration projects.
c. Promote wetland construction to assimilate nutrient loadings.

Buffer Initiative Program - SCC

a. Install grass buffer strips near streams.
b. Leverage Conservation Reserve Enhancement Program to hold riparian land out of production.

Extension Outreach and Technical Assistance - Kansas State University

a. Educate agricultural producers on sediment, nutrient, and pasture management.
b. Educate livestock producers on livestock waste management and manure applications and nutrient management planning.

c. Provide technical assistance on livestock waste management systems and nutrient management plans.
d. Provide technical assistance on buffer strip design and minimizing cropland runoff.
e. Encourage annual soil testing to determine capacity of field to hold nutrients.

Time Frame for Implementation: Water quality improvement activities are encouraged at the local level prior to 2008. Funding for installing lake pollution reduction practices should be allocated within the lake drainage after the year 2008. Evaluation of nutrient sources to lake and identification of potential management techniques should occur prior to 2008.

Targeted Participants: Primary participants for implementation will be agricultural producers within the drainage of the lake. Initial work in 2008 should include local assessments by conservation district personnel and county extension agents to locate within the lake drainage:

1. Total row crop acreage
2. Cultivation alongside lake
3. Drainage alongside or through animal feeding lots
4. Livestock use of riparian areas
5. Fields with manure applications

Milestone for 2008: The year 2008 marks the midpoint of the ten-year implementation window for the watershed. At that point in time, sampled data from Waconda Lake should indicate probable sources of nutrients and plans in place to initiate implementation.

Delivery Agents: The primary delivery agents for program participation will be the Kansas Department of Wildlife and Parks. Producer outreach and awareness will be delivered by Kansas State Extension.

Reasonable Assurances:

Authorities: The following authorities may be used to direct activities in the watershed to reduce pollutants.

1. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.

2. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.

3. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control nonpoint source pollution.

4. K.S.A. 82a-901, et seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.

5. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan.*

6. The *Kansas Water Plan* and the Solomon Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

Funding: The State Water Plan Fund annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollutant reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are a Medium Priority consideration.

Effectiveness: Nutrient control has been proven effective through conservation tillage, contour farming and use of grass waterways and buffer strips. The key to success will be widespread utilization of conservation farming and installation of buffer strips within the watersheds cited in this TMDL.

6. MONITORING

Additional data, to further determine source loading and mean summer lake trophic condition, would be of value prior to 2008. Further sampling and evaluation should occur once before 2008 and once between 2008 and 2012. Some monitoring of tributary levels of nutrients will help direct abatement efforts toward major contributors.

7. FEEDBACK

Public Meetings: Public meetings to discuss TMDLs in the Solomon Basin were held January 7 and March 3, 2003 in Stockton. An active Internet Web site was established at http://www.kdhe.state.ks.us/tmdl/ to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Solomon Basin.

Public Hearing: A Public Hearing on the TMDLs of the Solomon Basin was held in Stockton on June 2, 2003.

Basin Advisory Committee: The Solomon Basin Advisory Committee met to discuss the TMDLs in the basin on October 3, 2002, January 7, March 3, and June 2, 2003.

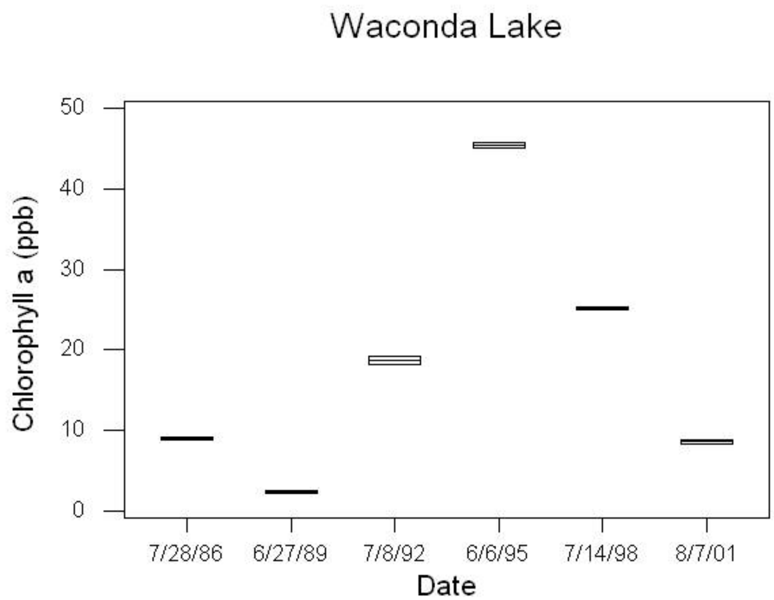
Milestone Evaluation: In 2008, evaluation will be made as to the degree of implementation which has occurred within the watershed and current condition of Waconda Lake. Subsequent decisions will be made regarding the implementation approach and follow up of additional implementation in the watershed.
Consideration for 303(d) Delisting: The lake will be evaluated for delisting under Section 303(d), based on the monitoring data over the period 2008-2012. Therefore, the decision for delisting will come about in the preparation of the 2012 303(d) list. Should modifications be made to the applicable water quality criteria during the ten-year implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities may be adjusted accordingly.

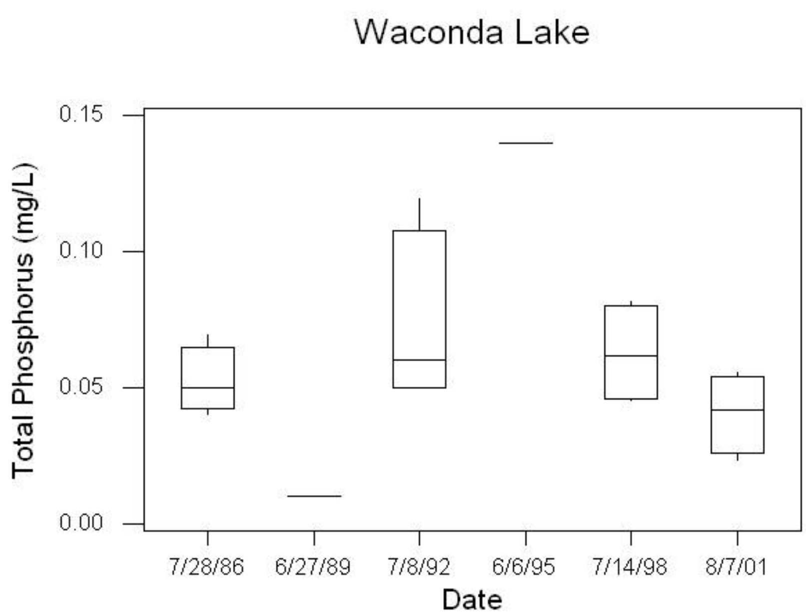
Incorporation into Continuing Planning Process, Water Quality Management Plan and the Kansas Water Planning Process: Under the current version of the Continuing Planning Process, the next anticipated revision will come in 2004 which will emphasize revision of the Water Quality Management Plan. At that time, incorporation of this TMDL will be made into both documents. Recommendations of this TMDL will be considered in *Kansas Water Plan* implementation decisions under the State Water Planning Process for Fiscal Years 2004-2008.

Bibliography

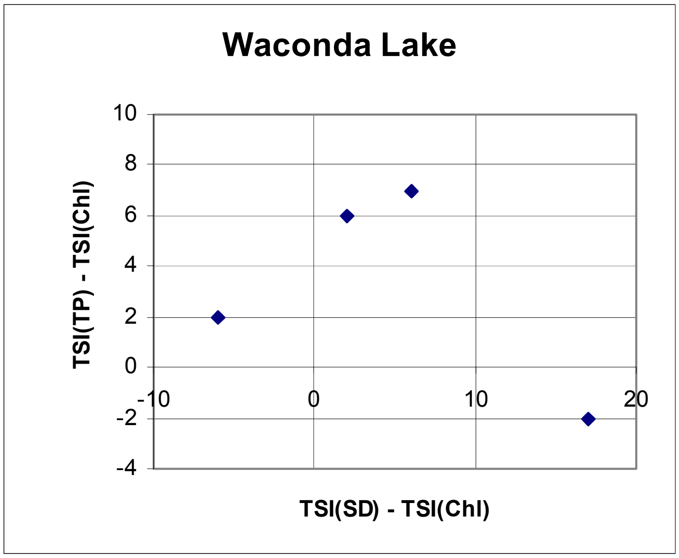
Liscek, Bonnie C. Methodology Used in Kansas Lake TMDLs [web page] Jul. 2001; http://www.kdhe.state.ks.us/tmdl/eutro.htm [Accessed 30 September 2002].

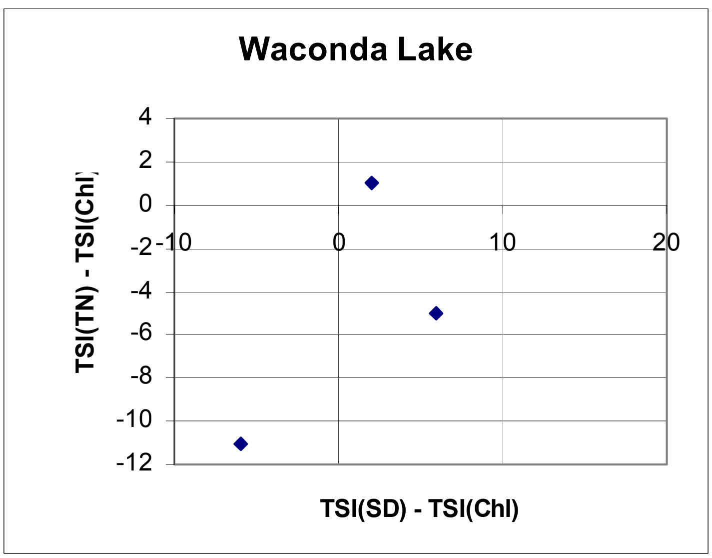
Appendix A - Boxplot





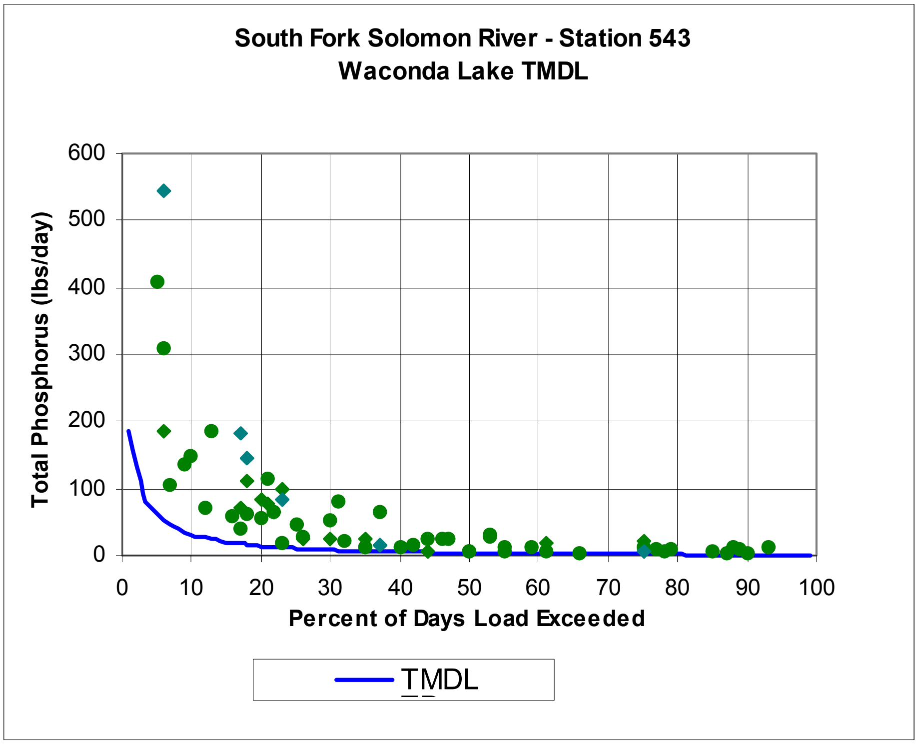
Appendix B - Trophic State Index Plots

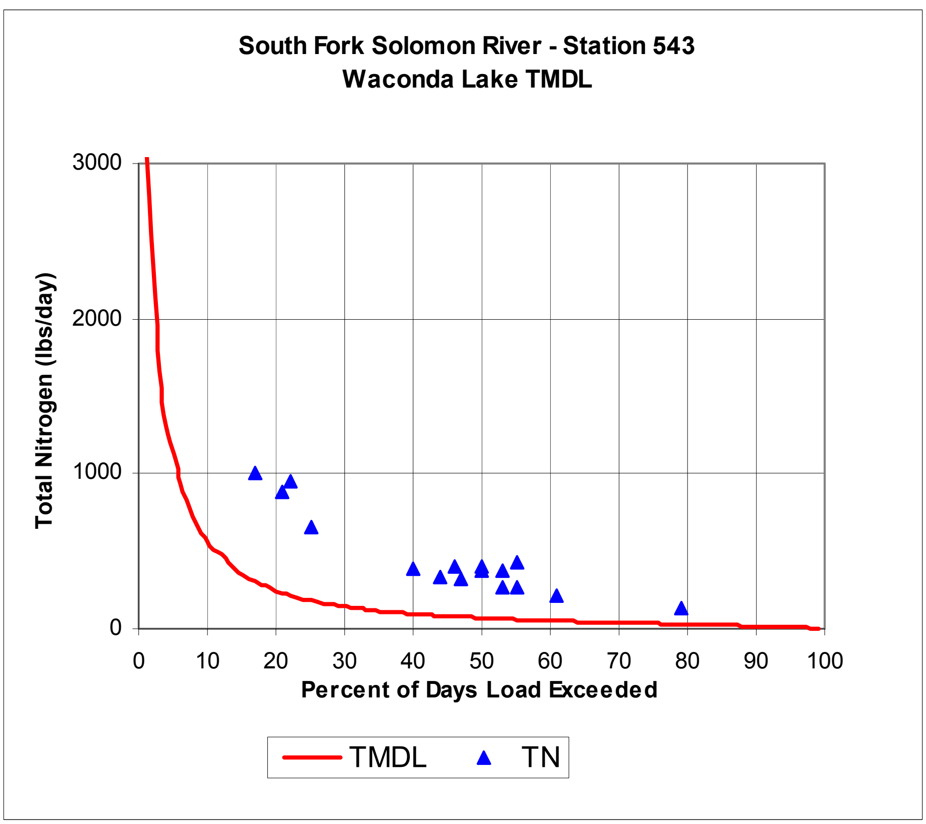


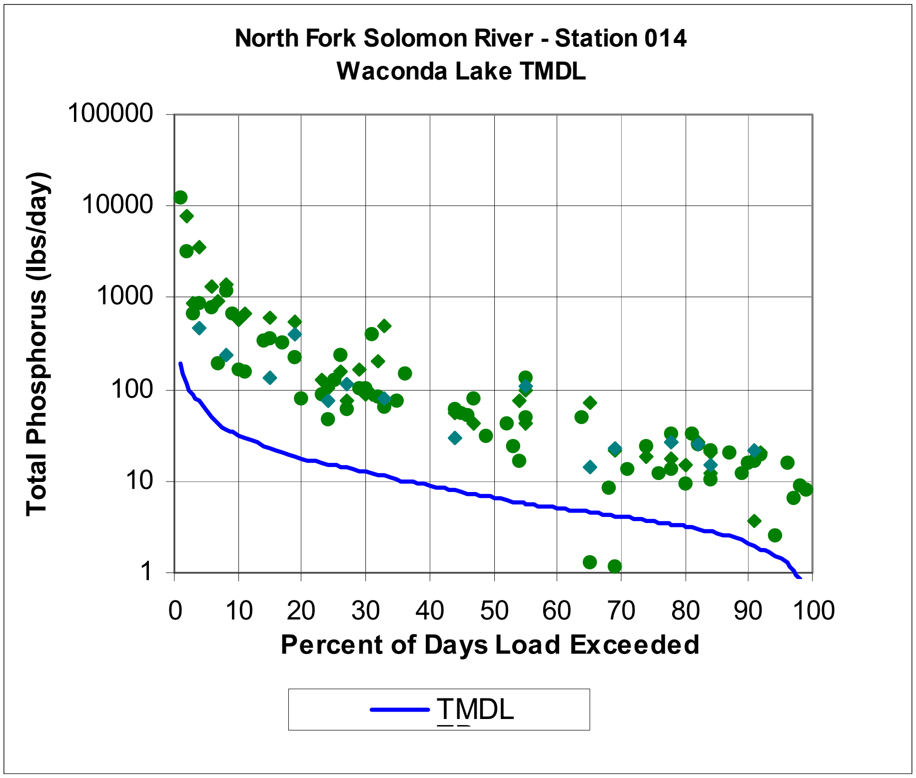


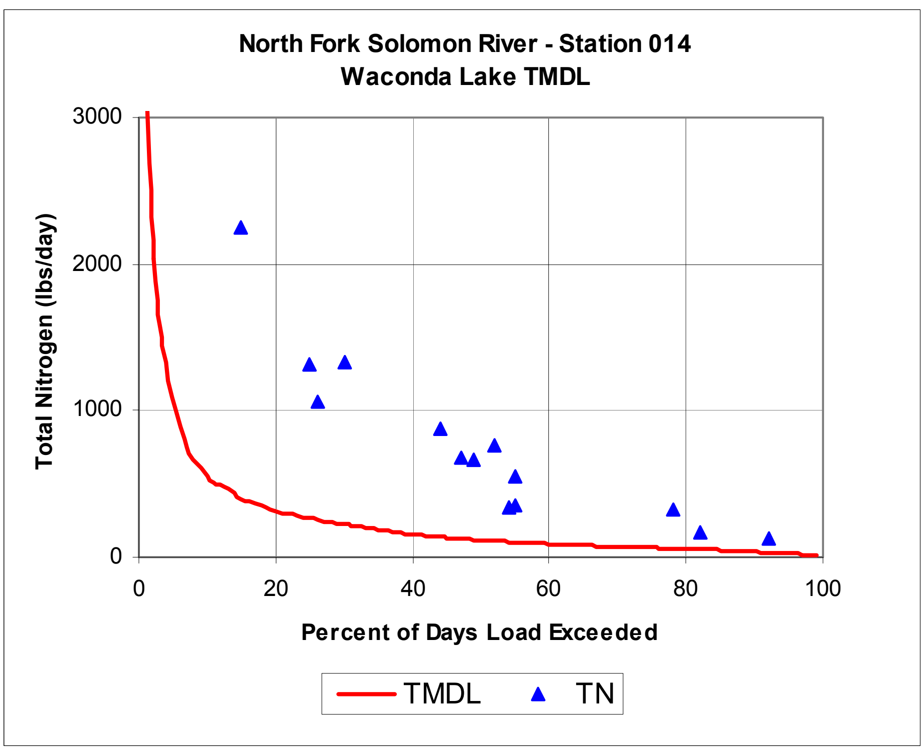
The Trophic State Index plots indicate that light is the primary limiting factor, due to clay turbidity. This is inferred by examining the relationship between the TSI(SD) - TSI(Chl) and TSI(TP)-TSI(Chl). The deviation of chlorophyll from the sediment load indicates the degree of light penetration, while the difference between chlorophyll and phosphorus indicates the level of phosphorus limitation. Therefore, if the final plot is in the first quadrant, it shows that the transparency of the water is impaired due to the presence of small particles, and that phosphorus does not limit algae growth. The positive slope of the graph also indicates a correlation between phosphorus and transparency which is found when phosphorus is bound to non algal particles. The relationship between the TSI(SD) - TSI(Chl) and TSI(TN)-TSI(Chl) indicates that nitrogen may be a secondary limiting factor.

Appendix C - Load Duration Curves






North Fork Solomon River - Station 014
Waconda Lake TMDL
Total Phosphorus (lbs/day)
100000
10000
1000
100
10
1
0 10 20 30 40 50 60 70 80 90 100
Percent of Days Load Exceeded
TMDL


North Fork Solomon River - Station 014
Waconda Lake TMDL
Total Nitrogen (lbs/day)
3000
2000
1000
0
0 20 40 60 80 100
Percent of Days Load Exceeded
TMDL
TN

Appendix D - Input for CNET Model

Parameter	**Value Input into CNET Model**
Drainage Area (km^2)	6448
Precipitation (m/yr)	0.61
Evaporation (m/yr)	1.48
Unit Runoff (m/yr)	0.03
Surface Area (km^2)	39.6
Mean Depth (m)	5.7
Depth of Mixed Layer (m)	5.0
Depth of Hypolimnion (m)	1.6
Observed Phosphorus (ppb)	56.0
Observed Chlorophyl-a (ppb)	18.2
Observed Secchi Disc Depth (m)	1.2

Output from CNET Model

Parameter	**Output from CNET Model**
Load Capacity (LC)*	**114,167 lb/yr**
Waste Load Allocation (WLA)	**16,370 lb/yr**
Load Allocation (LA)	**86,380 lb/yr**
Margin of Safety (MOS)	**11,417 lb/yr**

***LC = WLA + LA + MOS**

Approved Sep. 30, 2003